

Air Pollution and Cigarettes



Air Pollution

- Exacerbates symptoms of respiratory and cardiovascular disease
- Is statistically associated with other adverse health effects
- Is a problem that deserves serious attention and action



Statements comparing air
pollution to smoking cigarettes
have appeared in some Utah
newspapers



My concern exists on several levels

- The statements grossly minimize the health effects of smoking.
- Smoking is one of the leading causes of preventable death in the US.
- Nicotine and cancer put cigarettes in a league of their own.



Breathing outdoor air is not
like smoking cigarettes.



Statistical correlations have limitations

They are limited in their ability to shed light on

- Causality
- Plausibility



Plausibility

- Fortunately, the relationship between a dose and a biological effect - a proven principle in the sciences of pharmacology and toxicology – is quantifiable and can be used to test plausibility in this instance.



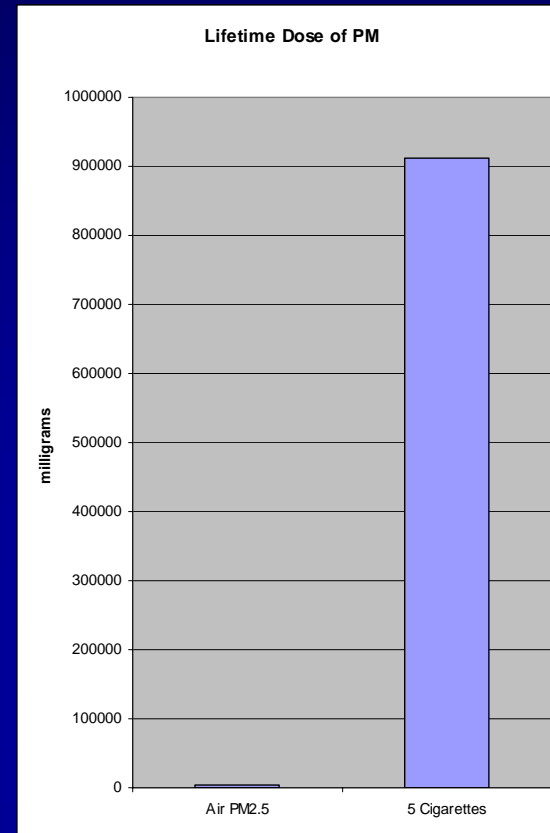
Dose of PM - Cigarettes

- 10 milligrams PM per cigarette
- 1 milligram PM nicotine per cigarette
- 5 cigarettes per day for 50 yrs = 912,500 milligrams PM.
- 5 cigarettes lifetime = $1/5^{\text{th}}$ pound of nicotine
- 5 cigarettes lifetime = 2 pounds PM



Dose of PM2.5 - Air

- Average daily dose = 0.2 mg
- Lifetime dose = 0.0097 pounds
- Aside from the issue of carcinogenicity, the dose of PM2.5 in air is 1/200th of that from 5 cigarettes.



Analysis of Relative Risk

- Assuming a linear dose/response based solely on total weight of PM breathed into the body, and assuming that smoking a pack a day shortens life by 8 years; smoking 5 cigarettes a day would shorten life by 2 years, and breathing Utah air might be estimated to shorten life by 3.5 days.



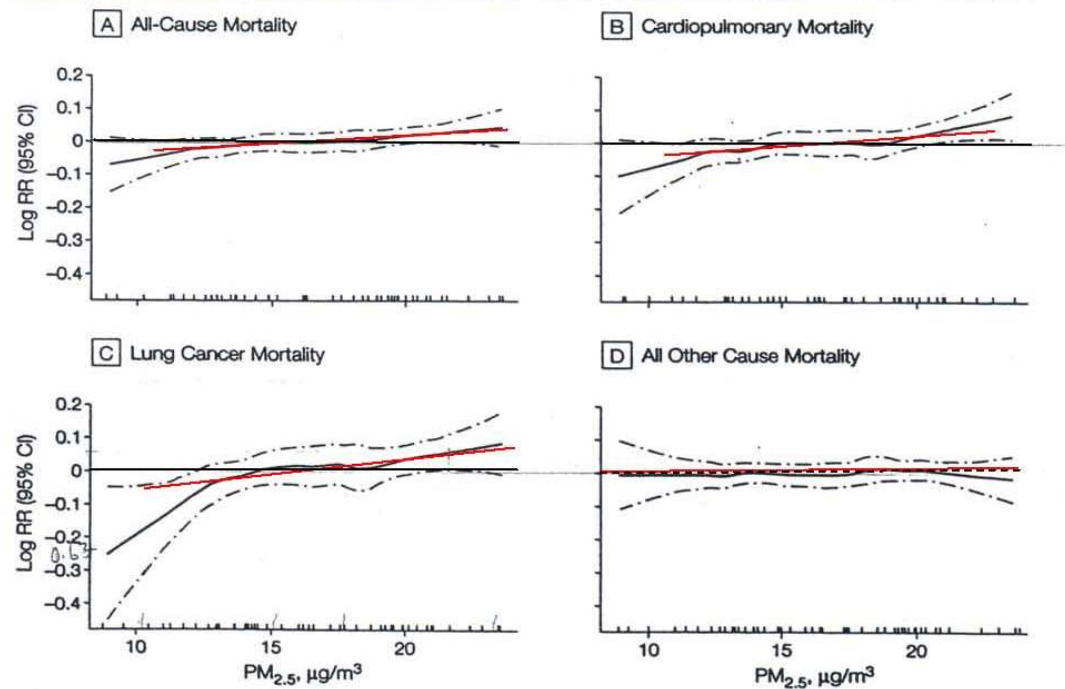
Breathing outdoor air is not
like smoking cigarettes.



Pope, A. C. et al. "Lung Cancer, Cardiovascular Mortality, and Long-term Exposure to Fine Particulate Air Pollution." JAMA, March 6 2002 – Vol. 287, No. 9.

- [A] 4% RR per 10 $\mu\text{g}/\text{m}^3$
- [B] 6% RR per 10 $\mu\text{g}/\text{m}^3$
- [C] 8% RR per 10 $\mu\text{g}/\text{m}^3$
- [D] Not significant

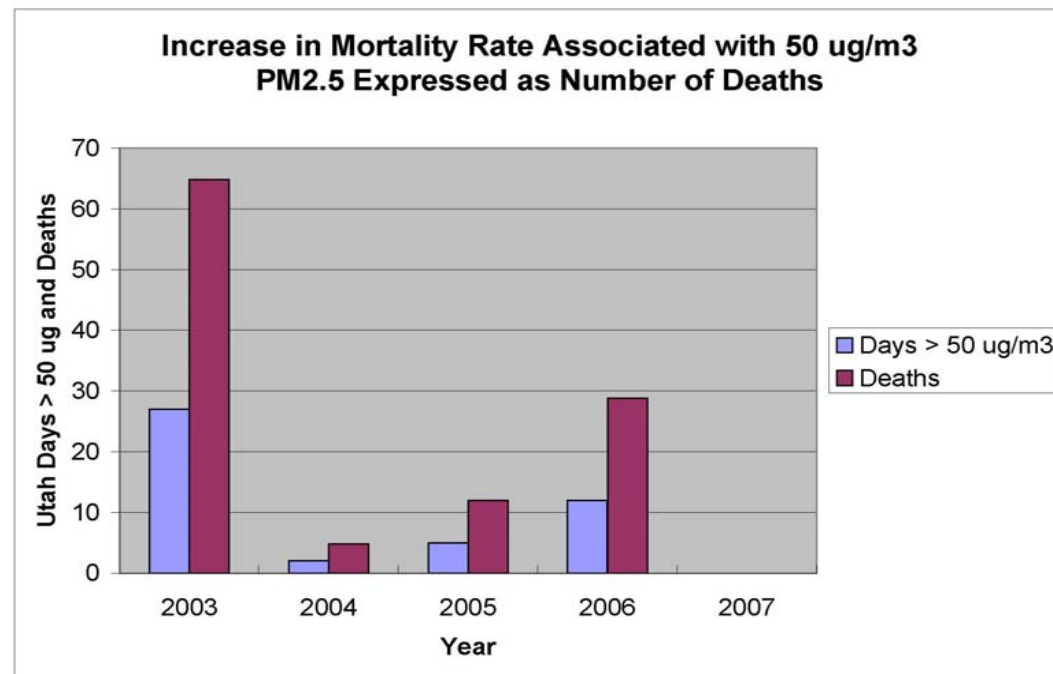
Figure 2. Nonparametric Smoothed Exposure Response Relationship



Vertical lines along x-axes indicate rug or frequency plot of mean fine particulate pollution; $\text{PM}_{2.5}$, mean fine particles measuring less than 2.5 μm in diameter; RR, relative risk; and CI, confidence interval.

Pope, A. C. and Dockery, D. W. "Health Effects of Fine Particulate Air Pollution: Lines that Connect." *Journal of the Air & Waste Management Association*. Vol. 56, 709-742, June 2006..

- 50 ug/m³ associated with 5% RR
- RR = 23.5 deaths per day per million population
- 2.4 deaths per 50 ug/m³ in Utah



Citizens concerned about air quality are important allies to public agencies charged with enforcing air standards.



Every reasonable action, based on good science and verifiable facts, should be taken to improve air quality and the quality of life of those who feel even temporary effects of air pollution.

Thank you.



AIR POLLUTION AND CIGARETTES

The quality of the air we breathe is vitally important. Air pollution exacerbates symptoms associated with respiratory and cardiovascular disease, and is statistically associated with other adverse health effects. Sensitive groups feel the effects of air pollution even before federal air standards are exceeded. It is a problem that deserves serious attention and action.

Statements comparing air pollution to smoking five to ten cigarettes per day have recently appeared in some Utah newspapers. My concern over such comparisons exists on several levels. Most importantly, comparisons such as this grossly minimize the serious health effects of smoking, which is one of the leading causes of preventable death in the United States. Nicotine addiction and cancer put cigarettes in a league of their own. Breathing outdoor air, even on bad days, is not like smoking cigarettes.

Certain statistics may have led to comparing cigarettes to air pollution, but studies based solely on statistical correlations are fundamentally limited in their ability to shed light on two important factors, namely causation and plausibility. Fortunately, the relationship between a dose and a biological effect - a proven principle in the sciences of pharmacology and toxicology - is quantifiable and can be used to test plausibility in this instance. Consider these facts:

One cigarette delivers up to 10 milligrams of soot and tiny particles into the lungs. One-tenth of these tiny particles are nicotine. Assuming five cigarettes a day for fifty years, a lifetime dose of 912, 500 milligram of particulate matter (PM) can be calculated. This represents a lifetime dose of $1/5^{\text{th}}$ of a pound of nicotine and over two pounds of particulate matter containing at least 19 known carcinogens.

Utah's air pollution in the form of tiny particles is called PM 2.5 with "2.5" denoting the maximum size, or diameter, of the tiny particles that are collected and weighed each day by the Utah Division of Air Quality. Using the measured weight of PM2.5 averaged over certified monitoring stations in Utah and the volume of air breathed in 24 hours one can estimate an average daily dose of 0.2 mg (.0000004 lbs), and a lifetime dose of 0.0097 pounds. Aside from the issue of carcinogenicity, the dose of particulates in air per day and per a lifetime is 200 times smaller than that from five cigarettes a day.

Citizens concerned about air quality are important allies to public agencies charged with enforcing air standards. But exaggerated claims by public agencies or citizens regarding pollution and its impact on health are as counterproductive to finding a solution to the problem as personal or public denial that there is a problem. Every reasonable action, based on good science and verifiable facts, should be taken to improve air quality and the quality of life of those who feel even temporary effects of air pollution.

Thank you.

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Dose of Particulate Matter: Cigarettes vs Utah Air

The amount of particulate matter (PM) taken into the body by an adult breathing outdoor air in Utah is calculated and compared with the dose of PM from cigarettes.

Dose Comparison: The dose of PM inhaled by a pack-a-day smoker is 833 times greater than the amount of PM inhaled by a person breathing Utah's outdoor air that averages 12 ug/m³. The dose inhaled from 5 cigarettes per day is 208 times greater.

Conclusion of Risk Analysis: Assuming a linear dose/response based solely on total weight of PM breathed into the body, and assuming that smoking a pack a day shortens life by 8 years; smoking 5 cigarettes a day would shorten life by 2 years, and breathing Utah air would be expected to shorten life by 3.5 days.

DEFINITIONS and ASSUMPTIONS

A milligram (mg) is one-thousandth the weight of one cubic centimeter of water.

A microgram (ug) is one-thousandth of a gram. There are 454 grams in a pound

$$\text{ug} := 1 \frac{\text{mg}}{1000} \quad 1\text{lb} = 453.592 \cdot \text{gm} \quad 1\text{lb} = 453592 \cdot \text{mg} \quad 1\text{lb} = 453592370 \cdot \text{ug}$$

A cubic meter (m³) is equal to about 33 cubic feet, or 1.3 cubic yards

$$1\text{m}^3 = 35.3 \cdot \text{ft}^3$$
$$1\text{m}^3 = 1.3 \cdot \text{yd}^3$$

A liter (L) is equal to one-thousandth of a cubic meter.

$$1\text{m}^3 = 1000 \cdot \text{L} \quad 1\text{L} = 61 \cdot \text{in}^3 \quad \sqrt[3]{1\text{L}} = 3.94 \cdot \text{in}$$

Dose refers to the cumulative mass, or weight, of all physical particles inhaled over a specified period of time: For example, the dose of PM for one day is found by multiplying the PM concentration (ug/m³) times the volume (m³) of air inhaled in one day.

TPM and TSP refer to Total Particulate Matter and Total Suspended Particulate. The terms are essentially interchangeable (TPM/TSP).

An adult breathes between 13 and 18 m³ of air per day. A conservative volume of 20,000 L or 20 m³ is assumed for the following calculations. See David Layton "Metabolically Consistent Breathing Rates for use in Dose Assessments" Health Physics, 64(1): 22-36, January 1993.

The volume of a typical puff is 37 milliliters (mL). See: "Smoking by machines and people - A summary. BATCO (British-American Tobacco Company) document for Province of British Columbia 15 November 2000."

PM delivered per cigarette is between 7-17.5 mg. See: Jeffrey E Harris,* Chapter 5 in *The FTC Cigarette Test Method for Determining Tar, Nicotine, and Carbon Monoxide Yields of U.S. Cigarettes: Report of the NCI Expert Committee*. Smoking and Tobacco Control Monograph No. 7, Bethesda, MD: National Cancer Institute, 1996, p. 69.

* Department of Economics, Massachusetts Institute of Technology.

DOSE OF PM FROM A CIGARETTE

A "smoking machine" programmed to simulate a puff of 130 mL collects 3.0 mg of TPM. The dose of TPM per 37 mL puff as presented above in Definitions and Assumptions can be calculated as follows

$$3\text{mg} \cdot \left(\frac{37\text{mL}}{130\text{mL}} \right) = 1 \cdot \text{mg}$$

The stimated dose of 10 mg PM per cigarette can be calculated using smoking machine data and empirical measurements of smokers. A dose of 10 mg is comparable to the 7.5-17.5 mg range reported by Harris. See Note 3 regarding the use of the 10 puffs-per-cigarette as a working assumption.

10 puffs x 1 mg is 10 mg or 10,000 ug.

CIGARETTE := 10·mg

COMPARISON OF DOSE: CIGARETTE PM vs UTAH AIR PM2.5

DAILY DOSE: Air - PM2.5

Utah, since 2000, has averaged 12 ug of PM2.5 per cubic meter of air (m³).

$$\text{Daily}_{\text{UtahPM25}} := 12 \frac{\text{ug}}{\text{m}^3} \cdot 20000\text{L}$$

$$\text{Daily}_{\text{UtahPM25}} = 0.24 \cdot \text{mg}$$

DAILY DOSE: 5 cigarettes - PM

$$5 \cdot \text{CIGARETTE} = 50 \cdot \text{mg}$$

Smoking 5 cigarettes per day delivers 200 times more PM than Utah air.

$$\frac{5 \cdot \text{CIGARETTE}}{(\text{Daily}_{\text{UtahPM25}})} = 208$$

A pack a day delivers over 800 times more PM than Utah air..

$$\frac{20 \cdot \text{CIGARETTE}}{\text{Daily}_{\text{UtahPM25}}} = 833$$

ANALYSIS OF RELATIVE RISK:

Assumes a cigarette habit starting at age 18 and continuing for fifty years (i.e. smoking LifeTime = 50 yr).

Assume daily consumption of 20 cigarettes (a pack a day).

Assume that a pack a day shortens life by 8 hrs.

Daily dose of PM from 20 cigarettes

$$\frac{20 \cdot \text{CIGARETTE}}{\text{day}} = 200 \cdot \frac{\text{mg}}{\text{day}}$$

Daily dose of PM2.5 at 12ug/m3

$$\frac{\text{Daily}_{\text{UtahPM25}}}{\text{day}} = 0.24 \cdot \frac{\text{mg}}{\text{day}}$$

Difference in annual dose of PM; pack a day dose minus ambient PM2.5 dose

$$\text{AnnualDose}_{\text{Cigarette}} := 365 \frac{\text{day}}{\text{yr}} \cdot \frac{20 \cdot \text{CIGARETTE}}{\text{day}}$$

$$\text{AnnualDose}_{\text{Cigarette}} = 73000 \cdot \frac{\text{mg}}{\text{yr}}$$

$$\text{AnnualDose}_{\text{Air}} := 365 \frac{\text{day}}{\text{yr}} \cdot \frac{\text{Daily}_{\text{UtahPM25}}}{\text{day}}$$

$$\text{AnnualDose}_{\text{Air}} = 87.6 \cdot \frac{\text{mg}}{\text{yr}}$$

Difference in annual dose.

$$\text{AnnualDose}_{\text{Cigarette}} - \text{AnnualDose}_{\text{Air}} = 72912.4 \cdot \frac{\text{mg}}{\text{yr}}$$

Relative magnitude (ratio) of annual doses

$$\frac{\text{AnnualDose}_{\text{Cigarette}}}{\text{AnnualDose}_{\text{Air}}} = 833$$

Lifetime dose of PM2.5

$$\frac{\text{Daily}_{\text{UtahPM25}}}{\text{day}} \cdot \frac{365 \text{ day}}{\text{yr}} \cdot 50 \text{ yr} = 0.0097 \cdot \text{lb}$$

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Draft

Added increase in PM dose from smoking a pack a day for 50 yrs.

LifeTime := 50yr

Expressed in grams

$$\frac{\text{LifeTime} \cdot (\text{AnnualDose}_{\text{Cigarette}})}{\text{LifeTime}} = 3650000 \cdot \frac{\text{mg}}{\text{LifeTime}}$$

$$\frac{\text{LifeTime} \cdot (\text{AnnualDose}_{\text{Cigarette}})}{\text{LifeTime}} = 8 \cdot \frac{\text{lb}}{\text{LifeTime}}$$

Relative magnitude of lifetime doses

$$\frac{\frac{\text{LifeTime} \cdot (\text{AnnualDose}_{\text{Cigarette}} - \text{AnnualDose}_{\text{Air}})}{\text{LifeTime}}}{\left(\frac{\text{LifeTime} \cdot \text{AnnualDose}_{\text{Air}}}{\text{LifeTime}} \right)} = 832$$

If 20 cigarettes a day (i.e., a pack a day) shortens life expectancy by 8 years, then Utah air might be expected shorten the average life span by 3.5 days..

$$\frac{8 \frac{\text{yr}}{\text{LifeTime}}}{\left[\frac{\frac{\text{LifeTime} \cdot (\text{AnnualDose}_{\text{Cigarette}} - \text{AnnualDose}_{\text{Air}})}{\text{LifeTime}}}{\left(\frac{\text{LifeTime} \cdot \text{AnnualDose}_{\text{Air}}}{\text{LifeTime}} \right)} \right]} = 3.5 \cdot \frac{\text{day}}{\text{LifeTime}}$$

NOTES

1. The foregoing comparisons and conclusions do not take into account
 - a) the difference in carcinogenic potency between ambient PM and cigarette smoke,
 - b) the health implications associated with the fact that 1.25 mg of the "delivered" PM per cigarette is nicotine, or
 - c) that cigarette smoke has a pH of about 5, plus or minus 0.5.
2. Utah Air Monitoring Center: HiVol samplers draw 16.7 L/min. In 24 hours this equals about 24,000 L which approximates the 20,000 L per-day-value typically used in modeling daily human respiratory volume.

$$16.7 \frac{\text{L}}{\text{min}} \cdot 60 \frac{\text{min}}{\text{hr}} \cdot 24 \text{hr} = 24048 \text{ L}$$

3. One reference that may be cited to support a 10 puff-per-cigarette input value.

Do work-place smoking bans cause smokers to smoke "harder"? Results from a naturalistic observational study

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Abstract

The purpose of this study was to investigate whether smokers outside buildings with work-place smoking bans smoke "harder" than those smoking in social settings. An unobtrusive random observational study of smokers followed by structured interview was used, with 143 smokers taking smoking breaks outside their office buildings and 113 smokers in social settings. The main outcome measurements were number of puffs per cigarette and cigarette smoking duration. The mean number of puffs per cigarette for the office building group was 18.7% greater than that for the social settings group (10.7±b13.2 vs. 8.7±b12.7, t = 5.58, df= 253, p < 0.001); 74.8% of smokers outside offices took more than the mean number of puffs for the group compared to 42.5% of smokers in social settings (χ² df 1 = 26.31, p < 0.0001). Mean cigarette smoking duration was 30.4% shorter for the work-place group than the social settings group (3.9 ±b1 1.2 minutes vs. 5.6 ±b1 2.6 minutes). Of smokers outside offices, 55.2% had a cigarette smoking duration between 3 and 4.59 minutes, while 53.1% of smokers in social settings took ≥5 minutes to smoke the observed cigarette (χ² df 2 = 31.55, p < 0.0001). Smokers who scored at the 75th percentile on the Fagerstrom Tolerance Scale took a mean 9.5 ±b12.6 puffs per cigarette compared to 9.3 ±b1 2.7 puffs by those who scored in the 25th percentile on the scale (1 = 0.34, df= 145, p = 0.73). Regardless of degree of nicotine dependency, smokers leaving work-stations to smoke outside buildings smoked their cigarettes nearly 19% "harder" than cigarettes smoked in social settings. The individual and public health benefits of reduced smoking frequency engendered by work-place smoking bans may be lessened by policies which allow smokers to take smoking breaks.